Committee on Resources

Subcommittee on Energy & Minerals Resources

Witness Statement

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Before

SUBCOMMITTEE FOR ENERGY AND MINERALS,

HOUSE COMMITTEE ON RESOURCES

Bill HR 1753 `Methane Hydrate Research and Development Act of 1999'

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Thank you, Madam Chairman and members of the Subcommittee for giving me the opportunity to present an outline of the state of our knowledge of natural gas hydrates and the future research needs in this area.

Natural gas hydrates have been known to exist within the continental margin sediments for several decades now, however, it is only during the last decade that the pace of research into their distribution and nature has picked up, and especially in the last three or four years. The research effort in several countries has been focused at learning more about their efficacy as an alternative energy resource. In addition, their role in slope instability and global climate change is also of considerable interest to the research community and has obvious societal relevance.

Gas hydrates consist of a mixture of methane and water and are frozen in place in marine sediments on the continental slope and rise. To be stable the hydrates require high pressure and low bottom temperature and thus they occur mostly at the depths of the continental slope (generally below 1500 feet depth). Due to the very low temperatures in the Arctic, hydrates also occur on land associated with permafrost, and at shallower submarine depths of about 600 feet. Methane gas that forms the hydrate is mostly derived from the decay of organic material trapped in the sediments.

Methane is a clean burning fuel. Because the methane molecule contains more hydrogen atoms for every carbon atom, its ignition produces less carbon dioxide than other, heavier, hydrocarbons. In addition, the hydrate concentrates 160 times more methane in the same space as free gas at atmospheric pressure at sea level. Thus, natural gas hydrates are considered by many to represent an immense, environmentally friendly, and viable, though as yet unproven resource of methane.

In marine sediments, hydrates are commonly detected by the presence of acoustic reflectors, know as bottom simulating reflectors, or BSRs. However, to produce a boundary that reflects acoustic energy, a significant quantity of free gas needs to be present below the hydrate to induce the contrast that causes the reflector. BSRs are known from many continental margins of the world, but hydrates have only rarely been sampled through drilling. Moreover, the presence or absence of BSR does not always correlate with the presence of hydrate nor provide information about the quantity of hydrate present. The general lack of direct sampling means that estimating the volumes of methane trapped in hydrates, or the associated free gas beneath the hydrate stability zone, remain largely speculative.

One of the few places in the world where hydrates have been drilled and directly sampled is on the Blake Ridge, a topographic feature off the coast of the Carolinas, Georgia and Florida. Here it was observed that the BSR is present only where there is significant amount of free gas below the hydrate, whereas hydrate was present even where there was no BSR recorded on acoustic profiles. Thus, if our estimates are calculated purely on the basis of observed BSRs, it may lead to underestimation of the lateral extent of the hydrate fields and the total volume of the contained methane.

Estimates of how much methane might be trapped in the hydrates in the nearshore sediments therefore remain conjectural at the present, but even the relatively conservative estimates contemplate as much as double the amount of all known fossil fuel sources. Whether or not these large estimates can be translated into a viable energy resource is a crucial question that has been the focus of researchers in many countries. In the past petroleum industry in the US and elsewhere has been less interested in methane hydrates as a resource because of the difficulties in estimating and extracting the gas and distributing it to consumers as a cost-effective resource.

Since gas hydrates in marine sediments largely occur on the continental slope, they may also be implicated in massive slumps and slides when hydrates break down due to increased bottom temperature or reduced hydrostatic pressure. Local earth tremors may also cause hydrates to slump along zones of weakness. When a hydrate dissociates, its bottom layer changes from solid "icy" substance to a "slushy" mixture of sediment, water and gas. This change in the mechanical strength of the hydrate occurs first near the base because the temperature in the sediment increases with depth and thus the bottom part of the hydrate stability zone is most vulnerable to subtle changes in temperature and pressure. This encourages massive slope failure along low-angle detachment faults. Such slumps can be a considerable hazard to petroleum exploration structures such as drilling rigs and to undersea cables. In addition, extensive slope failures can conceivably release large amounts of methane gas into the seawater and atmosphere.

Scientists studying the recent geological past theorize that gas-hydrate dissociation during the last glacial period (some 18,000 years ago) may have been responsible for the rapid termination of the glacial episode. During the glacial period the sea level fell by more than 300 feet, which lowered the hydrostatic pressure, leading to massive slumping that may have liberated significant amount of methane. Methane being a potent greenhouse gas (considered to be ten times as potent as carbon dioxide by weight), a large release from hydrate sources could have triggered greenhouse warming. As the frequency of slumping and methane release increased, a threshold was eventually reached where ice melting began, leading to a rapid deglaciation.

At present, however, the response of the methane trapped in the permafrost as hydrate is of greater concern. If the summer temperatures in the higher latitudes were to rise by even a few degrees, it could lead to increased emission of methane from the permafrost, thereby adding to the greenhouse effect and further raising the global temperatures. These increases in global mean temperature may also lead to further melting of high-latitude ice fields on Greenland and Antarctica. The response of both the permafrost and the ice fields to increased temperature, however, remains largely unknown at the present time.

Direct measurements of methane in hydrated sediments and the free gas below made during drilling on the Blake Ridge by the Ocean Drilling Program, supported largely by the National Science Foundation, show that large quantities of methane may be stored in this gas-hydrate field, and even more as free gas below the hydrate. In the hydrate stability zone the volume of the gas hydrate based on direct measurements was estimated to be between 5 and 9% of the pore space. Though the hydrate occurs mostly finely disseminated in the sediment, relatively pure hydrate bodies up to 30 cm thick also occur intermittently. Below the hydrate stability pore spaces are saturated with free gas. From the point of view of recoverability, the free gas below the hydrate stability zone, if it occurs in sufficient quantities, could be recovered first. Eventually, the gas hydrate may itself be dissociated artificially and recovered through injection of hot water or through depressurization.

Although the hydrocarbon industry has had a long-standing interest in hydrates (largely because of their nuisance value in clogging up gas pipelines in colder high latitudes and in seafloor instability for rig structures), their slowness in responding to the need for gas-hydrate research as an energy resource stems from several factors. Many in the industry believe that the widely cited large estimates of methane in gas hydrates on the continental margins may be overstated. Moreover, if the hydrate is thinly dispersed in the sediment rather than concentrated, it may not be easily recoverable, and thus not cost-effective to exploit.

One suggested scenario for the exploitation of such a dispersed resource is excavation, which is environmentally a less acceptable option than drilling. And finally, if recovering methane from hydrate becomes feasible, it may have important implications for slope stability. Since most hydrates occur on the continental slope, extracting the hydrate or recovering the free gas below the stability zone could cause slope instabilities of major proportions that may not be acceptable to coastal communities. Producing gas from gas hydrates locked up in the permafrost has so far met with considerable difficulties, as the Russian efforts to do so in Siberia in the 1960s and 70s would imply.

The occurrence and stability of gas hydrates at oceanic depths of the slope and rise has also led to the notion that we may be able dispose off excess green-house gases, especially carbon dioxide, in the deep ocean as artificial hydrates. Although permanent sequestration of carbon dioxide may not be realistic since the hydrate on the seafloor would eventually be dissolved and dispersed in seawater, the isolation of carbon dioxide in the form of solid hydrate that remains stable for relatively long periods of time may be plausible. The long time scales of ocean circulation, the large size of the oceanic reservoir and the buffering effect of carbonate sediments all speak in favor of this potentiality. These notions, however, need considerable measure of research, both in the laboratory and the field, before they can be regarded as practical.

Research Needs

Much of the uncertainty concerning the value of gas hydrates as a resource for the future, their role in slope instability and their potential as agents for future climate change, stems from the fact that we have little knowledge of the nature of the gas-hydrate reservoir. Understanding the characteristics of the reservoir and finding ways to image and evaluate its contents remotely may be the two most important challenges in gas-hydrate R & D for the near future.

We need to know where on land and the continental margins gas hydrates occur and how extensive is their distribution? We need to be able to discern how they are distributed, mostly thinly dispersed in sediments or in substantial local concentrations. Only then will we be able to come up with meaningful estimates of their total volume on the US continental margins and in higher latitudes, as well their global distribution.

We also need a better understanding of how hydrates form and how they get to where they are stabilized. This effort encompasses learning more about the biological activity and organic-matter decay that generates methane for hydrates, their plumbing systems, migration pathways and the hydrate thermodynamics, and it will require laboratory experimentation, field observations and modeling.

To understand the role of gas hydrates in slope instability, research will be needed to learn more about their physical properties and their response to changes in pressure-temperature regimes. Both laboratory experimentation and *in situ* monitoring will be necessary. Gas hydrates in the Arctic, Gulf of Mexico and off the US East Coast represent extensive natural laboratories for all aspects of gas hydrate research.

To appreciate the role of gas hydrates in global climate change, we need to have a better grasp of how much of the hydrate in the continental margins and the permafrost is actually susceptible to oceanic and atmospheric temperature fluctuations. More importantly, we must understand the fate of the methane released from a hydrate source into the water column and the atmosphere. Studies of the geological records of past hydrate fields can also provide clues to their behavior and role in climate change.

Once the efficacy of natural gas hydrate as a resource has been proven, new technologies will have to be developed for their meaningful exploitation. This includes new methodologies for detection, drilling, and recovery of the solid hydrate and the free gas below. Such technologies are lacking at the present time.

Madam Chairman, once again thank you for giving me the opportunity to testify and I will be happy to answer any questions from the members of the Subcommittee that I am able to.

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